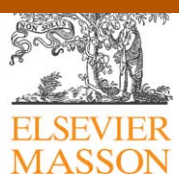
European Annals of Otorhinolaryngology, Head and Neck diseases (2011) **128**, 107—113



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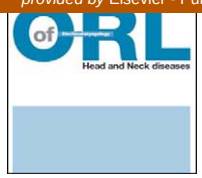

ORIGINAL ARTICLE

Patient satisfaction and functional results with the bone-anchored hearing aid (BAHA)

Enquête de satisfaction et résultats fonctionnels après réhabilitation auditive par prothèse ostéo-intégrée de type BAHA

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Available online 20 May 2011

KEYWORDS
BAHA;
Surgical technique;
Life quality;
Patient satisfaction;
Hearing results

Summary
Objectives: To assess patient satisfaction with bone-anchored hearing aids (BAHA) and the role of preoperative audiometric testing.
Patients and methods: A telephone satisfaction survey was conducted on all patients implanted between June 1, 2005 and February 1, 2008. Patients with unilateral total deafness underwent preoperative audiometric tests in quiet and in noise and stereoaudiometry with and without BAHA. Patients with a conductive hearing loss underwent preoperative audiometric tests in quiet and in noise and real-life testing at home using a headband. A standardized satisfaction questionnaire derived from the Entific BAHA questionnaire was used.
Results: Twenty-two out of 26 patients responded to the questionnaire. Ten patients were implanted for conductive hearing loss (CHL) and 12 for unilateral total deafness (UTD). Mean follow-up was 19 months in the UTD group and 21 months in the CHL group. Sixty-seven percent of UTD and 80% of CHL patients reported improved quality of life. The BAHA was worn for more than 4 hours per day by 83% of UTD and 100% of CHL patients, and at least 5 days per week by 67% of UTD and 80% of CHL patients.
Conclusion: BAHAs provided real benefit in all situations for CHL patients. In UTD, its benefit basically related to noisy environments. In UTD, satisfaction on preoperative stereoaudiometric testing in noise with and without BAHA was predictive of postimplantation satisfaction. In response to the question ''Would you do it again?'', 81% of patients answered ''Yes''.

Introduction

The idea of auditory rehabilitation using a bone-anchored hearing aid (BAHA) was born in 1977 and first reported by

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doi:10.1016/j.anorl.2010.09.009

Tjellström et al. [1,2]. The technique had been made possible thanks to Per-Ingvar Bränemark's work in the 1960s on the osseointegration of titanium implants, first in animals and then in the human oral cavity. BAHA was the first attempt at bone-anchored implantation outside of the oral cavity. The concept developed by the technique's precursors was to stimulate the cochlea by bone conduction. Although described more than a century ago, the physiology of this natural auditory pathway is still not fully understood. Von Békésy's experiments [3] on bone conduction showed that direct excitation of the cranium by a vibrator induces the same cochlear auditory transduction mechanisms as in air transmission [4]. Three bone conduction pathways are well known: relative movement of ossicles and temporal bone, bone compression, and sound radiating in the external ear canal. Sohmer and Freeman, in 2000 [5] and again in 2004 [6], described a new bone conduction pathway via the cerebrospinal fluid and cerebral soft tissue.

Indications for BAHA were initially conductive hearing loss (CHL) secondary to chronic otitis, non-amenable to management by conventional hearing aids (HA) or secondary to congenital middle or external ear malformation [7—9]: the use of BAHA does not presuppose tympano-ossicular system integrity. It has proved more effective in CHL than classical HAs that use bone conduction by simple contact of a vibrator against the skin [10]. Being anchored in the bone, the implant creates its own pathway, known as a direct bone conduction pathway, free of attenuation induced by the skin and subcutaneous soft tissue, which represents a gain of some 15 dB at conversation frequencies. [9]. More recently, indications for BAHA have been extended to unilateral total deafness (UTD) [11,12]. UTD is disabling for the understanding of speakers situated on the deaf side and of speech in noise. The BAHA overcomes the shadowing effect of the head by picking up sound on the deaf side and conducting it via a bone pathway to the hearing side. Thus a sound presented to a BAHA-equipped UTD subject is perceived by the healthy contralateral cochlea as two distinct acoustic signals, one from the implant via bone conduction and the other from the healthy ear; this artificial difference mimics physiological interaural difference.

The present study firstly investigated the benefit provided by BAHAs, in a satisfaction and quality of life survey. Results analysis took account of the underlying indication (conduction hearing loss or UTD). Secondly, the usefulness of preoperative audiometric testing for patient selection was assessed.

Patients and methods

Patients fitted with a BAHA were recruited via the institution's data coding system. All were implanted between June 1, 2005 and February 1, 2008. The study was twofold: a retrospective records analysis, and a telephone survey using a standardized questionnaire based on the Entific Medical Systems questionnaire. This questionnaire quantifies daily BAHA use in various situations and assesses resultant satisfaction and improvement in quality of life, on a numerical satisfaction scale [13] to which items on ease of HA handling were added, along with a final question: ''Would you do it again?'' (Appendix 1).

UTD patients underwent the following stereoaudiometric assessment [14]:

- vocal audiometry with two-syllable word lists in 65 dB HL noise (frontal white noise). Acoustic stimulus intensity levels were 60, 65 and 70 dB (voice source at 90° azimuth to the affected side [simplified Hirsh test]) with and without BAHA held by headband to the affected side;
- multidirectional HA gain test (tonal audiometry on five azimuths with and without BAHA held by head-band [Dehaussy test]);
- spatial location test (Decroix test).

CHL patients (group CHL) did not systematically undergo stereoaudiometry, but were in all cases assessed by:

- tonal audiometry;
- vocal audiometry with two-syllable word lists;
- open-field vocal audiometry with two-syllable word lists, with BAHA;
- real-life testing, using a headband worn at home for 2 weeks.

When an HA was already being worn, tests were repeated with and without HA.

Stereoaudiometry was considered positive if the mean vocal score in noise on the simplified Hirsh test exceeded 10% or if a mean vocal score in noise of less than 50% passed the 50% threshold with use of BAHA. These values were chosen by analogy to Hirsh test values for normal subjects, where separating voice and disturber sources improves mean vocal score by 10 to 25% [14].

Implantation was indicated for UTD patients if stereoaudiometry was positive or patient demand was strong, and for CHL patients if the real-life trial proved beneficial.

The same surgical procedure was performed in all 26 patients: a classical technique [15] involving a C-shaped flap without use of dermatome. The HA was implemented as of 2 months postoperatively.

Results

Twenty-six patients were identified from the institution's surgery coding system: 11 male, 15 female; mean age 47 ± 18 yrs, median 46.5 yrs, range 7—77 yrs.

Indications for implantation were:

- UTD (group UTD) in 14 cases (54%): three discovered in childhood, five secondary to vestibular schwannoma, three post-traumatic, one Menière's disease, one post-meningitis, and one secondary to otospongiosis surgery;
- CHL (group CHL) in 12 cases (46%): 10 chronic otitis sequelae, one following ear exclusion for external auditory canal carcinoma, and one severe unilateral aplasia.

Twenty-two of the 26 patients were contacted and responded to the questionnaire. Those not contacted comprised: two cases of extrusion of the percutaneous abutment, one HA removal at the patient's request, and one lost to follow-up (FU).

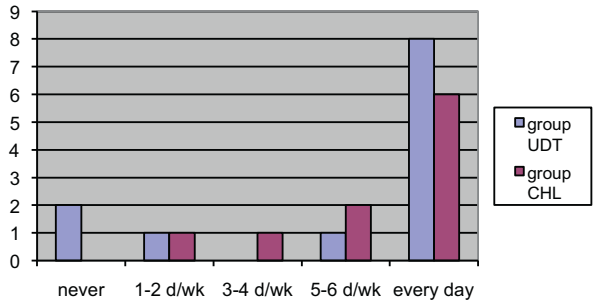

Figure 1 BAHA use: days per week.

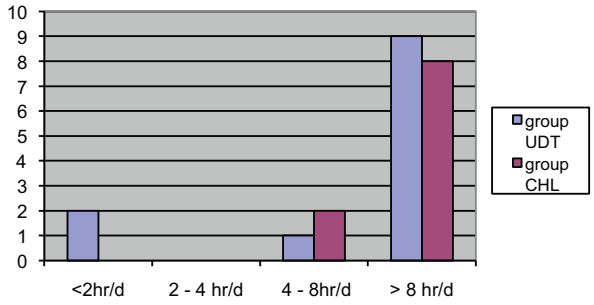

Figure 2 BAHA use: hours per day.

Mean FU was 20 ± 9 months (range, 3 months to 2 yrs 10 months).

Frequency of BAHA use

In group UTD

Twelve patients answered the questionnaire: five women and seven men; mean age 41.2 ± 16.1 years, range 7 to 67 yrs; mean FU, 19 ± 7.5 mo.

Eight patients (67%) used their BAHA every day, and nine (75%) for more than 8 hours a day. Two patients (17%) did not use it at all (Figs. 1 and 2).

In response to the question ''Has your quality of life improved because of the new device?'', eight patients (67%) answered positively. The mean score for the BAHA on the QoL grading scale was 6.9/10 with a median of 8/10.

Improvement in different situations was moderate to good overall, with better results for one-to-one conversation, and a tendency for results to be less good for watching television or listening to the radio or in a group situation (Fig. 3).

In response to the question ''In which situation is the BAHA most useful?'', no UTD patients responded ''In all these situations''. The BAHA rarely proved useful to UTD patients when they were alone at home (in the ''real-life'' test situation) (18%).

Conversely, in response to the question ''In which situation is the BAHA not useful?'', UTD patients always reported there being situations in which the BAHA provided no benefit; for 58% of UTD patients, this was the ''alone at home'' situation.

In group CHL

Ten patients responded to the questionnaire: seven women and three men; mean age, 54.5 ± 17.9 years (range, 20–77 yrs); mean FU, 21 ± 9 months.

The BAHA was very well used, 100% of patients using it more than 4 hours a day and 80% using it at least 5 days a week (Figs. 1 and 2).

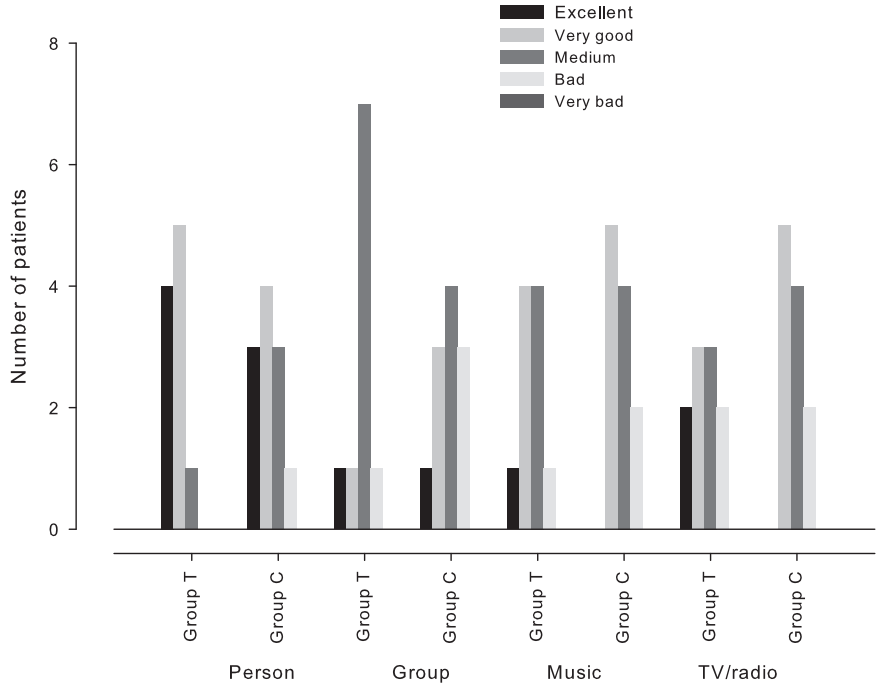

Figure 3 BAHA benefit according to situation. Person: 1-to-1; Group: group conversation; Music: listening to music; TV/radio: listening to television and/or radio.

Figure 4 Complete bone-anchor component (cutaneous abutment and osteofixture) after wound healing.

Eighty percent of CHL patients reported improved quality of life. The mean score for the BAHA on the QoL satisfaction grading scale was 8.5/10. Results were very good to excellent in all situations for most patients, except in the ''group'' situation, where they were moderate (Fig. 3).

Esthetic experience and handling

Seventy-six percent of patients found the BAHA discreet, one even finding it nice; no one was bothered by its esthetic aspect, but 19% found it not very discreet. Fifty-eight percent thought it looked nicer than a classical HA. The way it can be hidden under the hair was very well received (Fig. 4).

Handling was reported to be easy or very easy in 73% of cases (16/22); 27% graded it between ''okay'' and ''very difficult''. The mean age of those not finding the BAHA easy to handle was 60 years (median, 67 yrs). Daily maintenance was judged demanding by one patient; two reported never doing any maintenance.

Comparison between preoperative audiometry data and overall postoperative satisfaction

In group UTD

Sound discrimination in noise was the determining factor in the indication. The tests of 10 of the 14 UTD patients were analyzed (two others could not be found, and two were performed elsewhere than our center). Eight showed more than 10% improvement in intelligibility in noise as defined by the simplified Hirsh test, with in all cases a mean vocal score in noise better than 50% using the BAHA. Mean satisfaction score was 8.4/10 on the questionnaire. Two patients were implanted despite non-satisfactory test results, as they reported subjective improvement on testing: one with UTD discovered in childhood (intelligibility in noise improved by 3%, but with a satisfaction score on the questionnaire of 7/10), and one whose initial test was at the borderline for positive, with 10% improvement in intelligibility in noise, but a very bad satisfaction score of 1/10.

In group CHL

Air-conduction tonal audiometry thresholds in the implanted ear varied from 68 dB to 120 dB loss: given the thresholds in these extreme cases, audiometry was performed twice, with appropriate masking, to be sure of the presence of a cochlear reserve. Bone-conduction thresholds varied from 10 to 57.5 dB loss. Mean conduction loss was 49.32 dB (range, 33 to 65 dB). Overall satisfaction was excellent, with a mean score of 8.7/10 and a median of 10. One patient scored his satisfaction at 1/10: he had been implanted after failure of iterative ossiculoplasty for chronic otitis, with air-conduction thresholds of −75 dB in the implanted ear and −47.5 dB contralaterally and a conduction loss of 51.5 dB. He made little use of the BAHA, although he found it useful in one-to-one discussion and when watching television or listening to music. His BAHA broke down twice, which may account for his dissatisfaction.

Discussion

In studying the results, two important points emerged from the present series: the satisfaction obtained with the BAHA was considerable for both conductive hearing-loss and UTD patients. A large majority of those satisfied with their BAHA on the preoperative trial were also satisfied postoperatively.

The patients surveyed were satisfied with their BAHA, in agreement with other reports.

In the CHL group, the mean satisfaction score was 8.5/10, in agreement with the series reported by Hakansson et al. [16] (mean, 8.7/10) and Badran et al. [17] (mean, 8.2/10). It is well established that daily and weekly HA use time correlates with benefit. The present series showed a high level of use (100% > 4 hours per day and 80% > 4 days per week), as reported elsewhere: 93% of patients using their BAHA everyday according to Dutt et al. [13] and 81% according to Badran et al. [17]. Daily use was similar to that in other series: more than 4 hours a day in 78% of cases according to Wazen [18], in 87% according to Tjellström [9] and in more than 90% according to Hakansson [16] and Dutt [13]. This level of use was also reported to be sustained, at more than 10 hours per day more than 10 years after implantation [18].

Ninety percent of patients found the BAHA good or excellent in one-to-one conversation, versus 20% in group discussion. This large difference is found in all studies: 85% vs. 45% according to Badran [17], 94% vs. 49% according to Hakansson [16], and 84% vs. 67% according to Dutt [13]. For use with music, television and radio, satisfaction scores were moderate; very few patients chose either ''excellent'' or ''very bad'' as responses: only 10% with respect to music, and 20% with respect to the radio. Even so, the BAHA was useful: 80% found it moderately useful for listening to music and 60% for watching television. It was less effective in such situations than in one-to-one conversation, but nevertheless useful. This was confirmed in other series, in which satisfaction with BAHA with respect to music or radio was high: e.g., 66% of ''very good'' or ''excellent'' responses for Badran [17] and 74% for Hakansson [16].

Another way of showing the interest of BAHAs is to assess perceived usefulness across situations: most patients find their BAHA useful in ''all situations'', and very few find it ''never useful''.

Finally, 80% of conductive hearing-loss patients reported improved quality of life with the use of their BAHA.

In the UTD group, the mean satisfaction score was 6.9/10: i.e., lower than in the CHL group. This is in agreement with other reports. Tringali [19] reported a score of 6.2/10 in the largest series published ($n = 118$), with a difference between CHL and USD groups much like in the present series: satisfaction 8.11 in CHL. Daily use exceeded 8 hours a day in 67% of cases and 4 hours a day in 75%. These results are slightly better than those reported by Tringali (48.5% > 8 hr/day and 81.5% > 4 hr/day) but lower than those usually found in the literature (78% > 8 hr/day for Hol [20] and 94% for Wazen [21]). This was due to our follow-up being longer than Hol's [20], and the fact that Wazen's [21] patients answered their questionnaire 1 month after implantation; but our series was much smaller than Tringali's [19].

In UTD, BAHAs are especially useful in group discussion, where sound may be coming from various speakers and directions, whereas they are mostly considered ''not useful'' by UTD patients when they are alone. Thus, while BAHAs do not restore true stereophonics, since the source of the sound cannot be located, perception in noise is nevertheless improved [22]. The satisfaction level for the use of BAHAs in group situations was higher in UTD than in CHL patients: 20% ''very good'' or ''excellent'' responses from CHL patients, versus 33% from UTD patients. The implant is useful in such situations.

Results regarding BAHA esthetics were very good: 75% of the patients found it discreet. It can easily be hidden in the hair. No psychological difficulty in wearing a visible bone-anchored implant emerged (Fig. 4). No patients in the present series reported any problems related to wearing a hat, unlike in the literature. It should be noted that the percutaneous abutment should be positioned low down in patients who wear hats.

Day-to-day use of BAHAs is easy: 73% of patients found them ''easy'' or ''very easy'' to handle. Acquisition was easy and quick for most patients, but gets harder with age: the six patients who reported difficulties of handling were elderly (median age, 67 years). Thus, before performing implantation, dyspraxia or the possibility of family members helping with handling (as in the case of two of the patients in the present series) need to be assessed.

Preoperative audiometry proved indispensable in UTD patients with a healthy contralateral ear. In case of positive stereoaudiometry results, the satisfaction level will be as high as in CHL patients. In the present series, one borderline test was associated with a bad postoperative result, while another bad test gave a reasonable result with satisfaction scored at 7/10 although the patient (a child, who disliked fitting the HA even though he did find improvement withy it) seldom wore the BAHA. In CHL, BAHAs gave very high levels of satisfaction. The risk of failure in this indication is thus very low, and implantation can be recommended whenever tolerance for conventional HAs is lacking.

Conclusion

BAHAs are effective, not bothersome, and well accepted by the patient. Overall benefit in terms of improved quality of life was significant in almost all cases, especially in CHL. In case of UTD, thorough preoperative assessment (audiometry in noise, age, esthetic judgment, working conditions and a practical trial of the BAHA using a headband) is highly advisable before deciding on implantation, in order to obtain the rate of success currently reported.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Appendix A.

BAHA questionnaire

Please take a few minutes to answer this questionnaire before your audiometric tests. It lets us assess your satisfaction with the hearing aid. This will help us weigh its pros and cons. Thank you for taking part in this study.

Surname: First name:

Please circle the answer that best matches your case (just one answer per question)

1) How many days a week do you use your BAHA?

- every day (7 days)
- almost every day (5—6 days per week)
- from time to time (3—4 days per week)
- sometimes (1—2 days per week)
- never

2) How many hours per day do you wear your BAHA?

- more than 8 hrs per day
- 4 to 8 hrs per day
- 2 to 4 hrs per day
- less than 2 hrs per day

3) Has your quality of life been improved by the BAHA?

- yes
- no
- sometimes yes, sometimes no
- no difference

4) Score your overall satisfaction or dissatisfaction with the BAHA on the numerical scale.

- 10: very satisfied
- 9
- 8
- 7
- 6
- 5: no difference with or without BAHA
- 4
- 3
- 2
- 1: dissatisfied

How would you rate the usefulness of the BAHA in the following situations?

5) Discussion with a single person:

— excellent
— very good
— moderate
— bad
— very bad

6) Discussion in a group:

— excellent
— very good
— moderate
— bad
— very bad

7) Listening to music

— excellent
— very good
— moderate
— bad
— very bad

8) Listening to radio or television

— excellent
— very good
— moderate
— bad
— very bad

9) How do you find the BAHA from an esthetic point of view?
a) Generally

— very esthetic
— discreet and not bothersome
— not very discreet, bothersome
— very bothersome

b) Compared to conventional hearing aids

— nicer
— less nice
— no difference

10) How do you rate handling the BAHA (clipping it onto the bone implant)?

— very easy
— easy
— okay
— difficult
— very difficult

11) Which situation is the BAHA most useful in?

— in noise
— in group
— one-to-one
— all these situations

12) Which situation is the BAHA not useful in?

— in noise
— in group
— one-to-one
— always useful

13) Would you do it again if you had to?

— yes
— no

If you met any problems, don't hesitate to ask. Thank you for your contribution to the study.

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